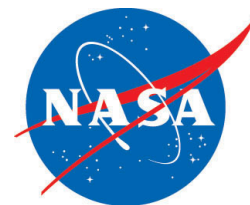


National Aeronautics and Space Administration



Volume 3
Space Shuttle Missions
2005 - 2008

chronology

2005

STS-114

*17th Space
Station Flight*



Discovery

Pad B:

114th shuttle mission
31st flight of OV-103
50th California landing

Crew:

Eileen Collins, commander (4th shuttle flight)
James Kelly, pilot (2nd)
Soichi Noguchi (JAXA), mission specialist (1st)
Stephen Robinson, mission specialist (3rd)
Andrew Thomas, mission specialist (4th)
Wendy Lawrence, mission specialist (4th)
Charles Camarda, mission specialist (1st)

Orbiter Preps:

OPF – Aug. 22, 2001; Oct. 24, 2001; Jan. 28, 2002; March 8, 2002; April 24, 2002; June 20, 2002; Aug. 22, 2002; March 29, 2005 (rollover)

VAB – Sept. 17, 2001 (storage); Nov. 28, 2001 (storage); April 17, 2002 (storage); June 14, 2002; June 26, 2002; July 2, 2002 (transfer aisle); May 26, 2005 (rollback)

Pad A – April 6, 2005; June 15, 2005

Launch:

July 26, 2005, at 10:39 a.m. EDT. A liquid hydrogen tank low-level fuel cut-off sensor failed a routine prelaunch check during the launch countdown July 13, causing mission managers to scrub Discovery's first launch attempt. Members of an engineering team met to review data and possible troubleshooting plans. Some of the troubleshooting included conducting electromagnetic interference and ground resistance testing on wiring in the aft engine compartment. On July 26, the countdown was flawless and liftoff occurred on time.

Landing:

Aug. 9, 2006, at 8:11:22 a.m. EDT. Landed on Runway 22, Edwards Air Force Base, Calif. Main gear touchdown: 8:11:36 a.m. Nose gear touchdown: 8:11:41 a.m. Wheel stop: 8:12:36 a.m. Rollout distance: 1.5 miles. Mission duration: 13 days, 21 hours, 32 minutes and 48 seconds. Landed on orbit 219. Logged 5.8 million miles. Waived off 2 landing opportunities on Aug. 9 at KSC due to weather. Landed on first opportunity at EAFB, marking the 6th night landing at Edwards and the 50th Shuttle landing in California. Kennedy Space Center was beset with weather issues starting Aug. 7, the original landing date. Several landing opportunities at Kennedy were waived off Aug. 8 and again Aug. 9. Edwards was chosen as the preferred landing site.

Mission Highlights:

Discovery's climb to orbit was extensively documented through a system of new and upgraded ground-based cameras, radar systems and airborne cameras aboard high altitude aircraft. The imagery captured of Discovery's launch, and additional imagery from laser systems on Discovery's new orbiter boom sensor system, or OBSS, laser-scanner as well as data from sensors embedded in the shuttle's wings, helped mission managers determine the health of Discovery's thermal protection system.

When Discovery neared the station early Thursday morning, Krikalev and Phillips used digital cameras and high-powered 800-mm and 400-mm lenses to photograph Discovery's thermal protective tiles and key areas around its main and nose landing gear doors. All imagery was downlinked to a team of 200 to analyze.

Before docking with the space station, Commander Eileen Collins performed the first rendezvous pitch maneuver about 600 feet below the station. The motion flipped the shuttle end over end at 3/4 degree per second, allowing Expedition 11 crew members to photograph the underside of Discovery and its heat-resistant tiles in detail.

Imagery during launch showed a piece of foam being shed from the external tank, as well as smaller tile and foam dings. Imagery of the tiles showed two areas where gap fillers were protruding.

Mission managers spent several days to determine if any action would be required of the crew. They finally decided to allow Robinson attempt to pull out the protruding gap fillers with his hand or with forceps, or remove the protrusions with a hacksaw. The astronauts reviewed training for using the robotic arm and worked on assembling a hacksaw should they need it.

A puffed-out piece of thermal blanket near the cockpit was identified in the imagery and became an-

other area of concern. Tunnel tests at NASA's Amers Research Center in California and further engineering analysis showed there was little reason to be concerned about debris release during re-entry.

Prior to the first spacewalk, Mission Specialist Wendy Lawrence and Pilot James Kelly guided the station's robotic arm, Canadarm2, to lift the multi-purpose logistics module, or MPLM, Raffaello from Discovery's cargo bay for attachment to the Unity module. More inspection of Discovery was conducted by Mission Specialist Charles Camarda and Kelly.

During the mission, astronauts tested and examined tiles in demonstration of repair techniques.

Other time was spent transferring equipment and supplies on the Station as well as removing and stowing the same on the MPLM Raffaello for return to Earth.

Three spacewalks were planned and conducted, including an add-on task for the gap filler removal:

EVA No. 1 — July 30: 6 hours, 50 minutes.

Mission Specialists Stephen Robinson and Soichi Noguchi worked with tiles and reinforced carbon-carbon intentionally damaged on the ground and brought into space in Discovery's cargo bay. They tested an emittance wash applicator for tile repair and non-oxide adhesive experimental for the reinforced carbon-carbon samples. They also installed a base and cabling for a stowage platform and rerouted power to control moment gyroscope-2, or CMG, one of four 600-pound gyroscopes that control the orientation of the station in orbit.

EVA No. 2 — Aug. 1: 7 hours, 14 minutes.

Noguchi and Robinson removed the failed CMG-1 and stowed it. They moved the new CMG from the payload bay and installed it. Four functioning CMGs now serve the space station.

EVA No. 3 — Aug. 3: 6 hours, 1 minute.

Attached to the Canadarm2, Robinson was moved to the site on Discovery's underside where he gently pulled the two protruding gap fillers from between thermal protection tiles. Other events were installing an external stowage platform outside the station to house spare parts and installing a fifth Materials International Space Station Experiment (MISSE). MISSE 5 exposes samples of various materials to the harsh space environment for several months.

Mission managers added one more day to the mission, to follow the third spacewalk. Both the Discovery crew and Expedition 11 crew paid tribute to the Columbia crew and other astronauts and cosmo-

nauts who have lost their lives in the human exploration of space.

The MPLM was unberthed from the Unity node using the robotic arm and placed back in Discovery's cargo bay. Discovery and the MPLM carried 7,055 pounds of unneeded equipment and trash. Both the Canadarm2 and OBSS were restored to their locations in the cargo bay.

2006

STS-121 *18th Space Station Flight*



Discovery

Pad B:

115th shuttle mission
32nd flight of OV-103
62nd KSC landing

Crew:

Steven Lindsey, commander (4th shuttle flight)
Mark Kelly, pilot (2nd)
Piers Sellers, mission specialist (2nd)
Michael Fossom, mission specialist (1st)
Lisa Nowak, mission specialist (1st)
Stephanie Wilson, mission specialist (1st)
Thomas Reiter, mission specialist (1st),
representing the European Space Agency (ESA)

Orbiter Preps:

OPF – Aug. 22, 2005
VAB – May 12, 2006
Pad B – May 19, 2006

Launch:

July 4, 2006, at 2:38 p.m. EDT. Launch of Discovery was scrubbed twice, July 1 and 2, due to weather concerns. After a day's standdown, the launch attempt resumed on July 4 and liftoff occurred on time.

Landing:

July 17, 2006, at 9:15 a.m. EDT. Landed on Runway 15 at KSC. Main gear touchdown: 9:14:43

a.m. Nose gear touchdown: 9:14:53 a.m. Wheel stop: 9:15:49 a.m. Rollout distance: 4.2 miles. Mission duration: 12 days, 18 hours, 37 minutes and 54 seconds. Logged 5.3 million miles. Landed on first opportunity at KSC, marking the 62nd landing at Kennedy.

Mission Highlights:

STS-121 was the second return-to-flight mission, demonstrating techniques for inspecting and protecting the shuttle's thermal protection system and replacing critical hardware needed for future station assembly. The mission also restored the station to a three-person crew for the first time since May 2003, leaving ESA astronaut Reiter aboard to join Expedition 13.

This was the most photographed shuttle mission in history, with more than 100 high-definition, digital, video and film cameras documenting the launch and climb to orbit. The images helped assess any damage sustained and potential risk for landing. In addition, the crew used the orbiter boom sensor system with a laser dynamic range imager, laser camera system and intensified television camera on the end, to examine the shuttle's nose cap, port wing, leading edge of the starboard wing, and outside of the crew cabin. No risk was found.

After docking to the station, the crew transferred the multi-purpose logistics module Leonardo to the Unity module from which they moved 7,400 pounds of supplies and equipment during their stay. The cargo included a new heat exchange for the common cabin air assembly that collects condensation out of the air on the station, a new window and window seals for the microgravity sciences glovebox, and a spare U.S. extravehicular activity suit and emergency jet pack.

Astronauts performed three spacewalks:

EVA No. 1 — July 8: 7 hours, 31 minutes.

Mission Specialists Piers Sellers and Michael Fossum installed a blade blocker on the S0 truss in the zenith interface umbilical assembly, or IUA, to protect the undamaged power, data and video cable. They rerouted the cable through the IUA in order to move the mobile transporter rail car and replace the trailing umbilical system with the severed power and data cable. After that task, they tested the combination of the shuttle robotic arm and OBSS as a platform for spacewalking astronauts to repair a damaged orbiter if ever needed. The EVA was the fourth for Sellers and first for Fossum.

EVA. No. 2 — July 10: 6 hours, 47 minutes.

Sellers and Fossum restored the station's mobile transporter car to full operation, replacing the nadir-side trailing umbilical system, including

a new interface umbilical assembly without a blade (the previous IUA had a blade, which inadvertently cut the cable that required the replacement). During the spacewalk, Fossum's emergency jet thruster backpack came loose on one side, requiring Sellers to secure it.

EVA No. 3 — July 12: 7 hours, 11 minutes.

The third and final spacewalk focused on testing repairs on thermal protection system reinforced carbon-carbon panels. Under evaluation was a pre-ceramic polymer sealant containing carbon-silicon carbide powder known as NOAX for use on damaged panels. Sellers and Fossum made three gouge repairs and two crack repairs. They also photographed the samples, as well as an area of Discovery's port wing.

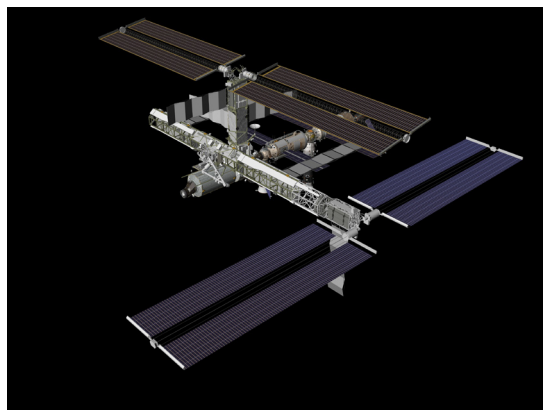
An added task during the EVA was removing the fixed grapple bar on the integrated cargo carrier in Discovery's payload bay and installing it on an ammonia tank inside the station's S1 truss to facilitate moving the tank on a later mission.

Refilled with 4,600 pounds of experiment samples, broken equipment and trash to be returned to Earth, Leonardo was moved back to Discovery's payload bay.

The return flight to Earth was delayed one day in order to add the third spacewalk. The mission management team determined there were enough consumables to extend the mission to test repair techniques and test a thermal imaging camera.

The trip home was one crew member short. Reiter remained behind to join Expedition 13, marking the first time since May 2003 that the station houses three crew members.

After unberthing from the station, the shuttle crew again used the robotic arm and boom sensors to inspect the starboard wing and nose cap heat shield. Still, no concerns were noted.



The International Space Station in August 2006.

STS-115

19th Space Station Flight

Atlantis

Pad B:

116th shuttle mission
27th flight of OV-104
63rd landing at KSC
15th night landing at KSC

Crew:

Brent Jett, commander (4th shuttle flight)
Christopher Ferguson, pilot (1st)
Joseph Tanner, mission specialist (4th)
Daniel Burbank, mission specialist (2nd)
Steven MacLean, mission specialist (2nd),
representing the Canadian Space Agency
Heidemarie Stefanyshyn-Piper, mission
specialist (1st)

Orbiter Preps:

OPF – Oct. 18, 2002
VAB – July 24, 2006
Pad B – Aug. 2, 2006

Launch:

Sept. 9, 2006, at 11:14:55 a.m. EDT. A lightning strike at the pad Aug. 25 caused the launch to slip to Aug. 27. As assessments of the strike's impact were conducted, Tropical Storm Ernesto threatened the Space Coast. Atlantis was rolled halfway back to the Vehicle Assembly Building on Aug. 29 for protection from the storm, but returned to the pad again on the same day after shuttle managers received a more favorable weather forecast.

Launch was rescheduled for Sept. 6 but a fuel cell problem occurred prior to tanking and the launch was scrubbed for 24 hours.

The crew boarded Atlantis again on Sept. 8 but the launch was again scrubbed 24 hours due to a faulty sensor reading.

Launch was successful Sept. 9.

Landing:

Sept. 21, 2006, at 6:21 a.m. EDT.

Atlantis landed on first opportunity, orbit 187, on Runway 33. Overall, the vehicle traveled 4,901,268 statute miles. Main gear touchdown was at 6:21:30 a.m. Nose gear touchdown was at 6:21:36 a.m.



Wheel stop was at 6:22:16 a.m. Rollout distance: 10,500 feet. Mission elapsed time was 11 days, 19 hours and six minutes.

The landing scheduled for Sept. 20 was postponed to allow for additional inspections of the spacecraft after video from cameras aboard the orbiter showed a piece of debris in proximity to the vehicle. The inspections included use of the orbiter boom sensor system and ensured all of Atlantis' critical equipment were in good shape.

Mission Highlights:

This mission resumed assembly of the International Space Station after a hiatus of four years.

Before the docking, the crew used the orbiter boom sensor system, the 50-foot-long extension for the shuttle's robotic arm, to inspect the reinforced carbon-carbon panels along the leading edge of Atlantis' starboard and port wings and the nose cap.

Approaching the space station, Commander Brent Jett flew Atlantis through an orbital back-flip while stationed 600 feet below the station to allow the Expedition 13 crew to photograph the orbiter's heat shield.

After the docking, Ferguson and Burbank attached the shuttle's robotic arm to the P3/P4 truss, lifted it from its berth in the payload bay, and maneuvered it for handover to the station's Canadarm2. After hatch opening, MacLean and Expedition 13 Flight Engineer Jeff Williams used the Canadarm2 to take the truss from the shuttle's robotic arm. MacLean was the first Canadian to operate the Canadarm2 in space.

Three spacewalks were later planned to install the P3/P4 integrated truss, deploy the solar arrays and prepare them for operation. A new procedure called a "camp out" was implemented, in which astronauts slept in the Quest airlock prior to their spacewalks. The process shortens the "prebreathe" time during which nitrogen is purged from the astronauts' systems and air pressure is lowered so the spacewalkers avoid the condition known as the bends.

EVA No. 1 — Sept. 12: 6 hours, 26 minutes.

Tanner and Piper connected power cables on the 17.5-ton, 45-foot-long truss, released the launch restraints on the solar array blanket box and on the beta gimbal assembly and the solar array wings. They also configured the solar alpha rotary joint, which allows the arrays to track the sun, and removed two other circuit interrupt devices to prepare for the STS-116 mission.

To access the launch locks on the solar alpha rotary joint, the astronauts had to remove existing covers. This was a "get-ahead" task originally scheduled for the following day. Tanner and

Piper's quick and efficient work enabled them to get ahead of the planned timeline. During this procedure on cover 21, a bolt and washer came off and floated into space.

EVA No. 2 — Sept. 13: 7 hours, 11 minutes.

First-time spacewalkers Dan Burbank and Steve MacLean released locks on the auto-sized solar alpha rotary joint, which allows the station's solar arrays to turn toward the sun. The locks had held the joint secure during its launch to orbit.

Minor problems occurred, including a malfunctioning helmet camera, a broken socket tool, a stubborn bolt requiring both astronauts to turn it, and a bolt that loosened from the mechanism designed to hold it.

EVA No. 3 — Sept. 15: 6 hours, 42 minutes.

Tanner and Piper powered up a cooling radiator for the newly unfolded solar arrays. They also replaced an S-band radio antenna that provides backup communications between the space station and the ground.

Other tasks, designed to reduce workload for future spacewalkers, included installing insulation for another communications antenna and (Tanner) taking photos of the shuttle's wings with an infrared camera to test its ability to detect damage.

After astronauts had prepared the solar alpha rotary joint for activation, Mission Control engaged the first of two drive-lock assemblies and rotated the joint 180 degrees. When they commanded the second drive-lock assembly to engage, they did not get an indication of engagement. A second command also failed. The glitch was resolved overnight.

The solar arrays on the newly delivered 17.5-ton truss segment were fully unfolded at 8:44 a.m. EDT on Sept. 14. During the unfurling, Atlantis' astronauts noted that some of the panels stuck. The phenomenon, called "stiction," also occurred during a shuttle mission in late 2000 when the station's first set of solar panels was deployed.

The power generated by the arrays will not be used by the station until mission STS-116, in December 2006, when astronauts will rewire the complex and activate a cooling system. The arrays currently are powering their own system, including batteries and other electronics equipment.

The solar panels have a wingspan of 240 feet attached on the port side of the station. They can generate 66 kilowatts of power.

The crew also maneuvered the Canadarm2 robotic arm in a "double walk off," moving it from the Mobile Base System to the Destiny Lab in an inch-worm-like procedure.

STS-116

20th Space Station Flight

Discovery

Pad B:

117th shuttle mission
33rd flight OV-103
64th landing at KSC

Crew:

Mark Polansky, commander (2nd shuttle flight)
William Oefelein, pilot (1st)
Robert Curbeam, mission specialist (3rd)
Joan Higginbotham, mission specialist (1st)
Nicholas Patrick, mission specialist (1st)
Christer Fuglesang, mission specialist (ESA) (1st)
Sunita Williams, mission specialist (1st), to ISS
(Thomas Reiter returning)

Orbiter Preps:

OPF – July 17, 2006
VAB – Oct. 31, 2006
Pad B – Nov. 9, 2006

Launch:

Dec. 9, 2006, at 8:47 p.m. EST. NASA managers postponed the Dec. 7 space shuttle launch attempt until Dec. 9 because of low cloud cover. The interim day's weather was not expected to be favorable for a launch attempt.

The Space Shuttle Discovery and its seven-member crew lifted off Dec. 9 from NASA's Kennedy Space Center in Florida on one of the most complex missions ever to the International Space Station.

Landing:

Dec. 22 at 5:32 p.m. EST. On KSC Runway 15. Nose gear touchdown was at 5:32:12 p.m. and wheel stop was at 5:32:52 p.m. Mission elapsed time was 12 days, 20 hours, 44 minutes and 16 seconds. This was the 64th landing at KSC.

The original landing date of Dec. 21 was postponed due to the addition of a fourth spacewalk. Inclement weather at KSC caused some concern and the first landing opportunity at 3:56 p.m. EST was waved off. The first chance for landing at Edwards Air Force Base in California was passed due to gusty winds. Weather conditions at KSC took a dramatic turn for the better and landing proceeded on the sec-



and opportunity.

Returning with the crew was astronaut Thomas Reiter after his six-month tenure as part of the Expedition 14 crew on the space station. He was replaced by Flight Engineer Suni Williams.

Mission Highlights:

Discovery rocketed into a dark Florida sky on the first night launch in more than four years. After reaching orbit, the crew used the shuttle's robotic arm and orbiter boom sensor system to examine Discovery's thermal protection system.

Docking with the International Space Station occurred at 4:12 p.m. Dec. 11. An impromptu wing inspection was called for after a minor vibration reading on the port wing sensor. The imagery analysis team determined the shuttle's heat shield could support a safe return to Earth and further inspection was not needed.

Three spacewalks (EVAs) were planned to unberth the P5 truss from Discovery's payload bay, install it on the station's main truss and rewire the station's electrical system to its permanent power grid.

Using a start-stop-restart process, the crew spent six hours Dec. 13 attempting to fold and retract the port array on the P6 integrated truss structure without success. Guidewires apparently snagged. Repeated attempts the next day were also unsuccessful. A fourth and unscheduled spacewalk was added to the mission to try again to loosen and retract the port array.

With the fourth EVA, Mission Specialist Robert Curbeam set a record for the most spacewalks during a shuttle mission. He has a total of 45 hours, 34 minutes of spacewalking time.

The total time spent on spacewalks on this mission was 25 hours, 45 minutes.

Before undocking from the station, Mission Specialist Joan Higginbotham and her cargo team transferred more than two tons of food, water and equipment for the Expedition 14 crew. They also filled Discovery's pressurized cargo carrier with equipment and experiment samples for return to Earth.

EVA No. 1 - Dec. 12: 6 hours, 36 minutes

Mission Specialists Curbeam and Christer Fuglesang attached the P5 truss and replaced a failed camera needed to support future assembly tasks. They completed additional tasks of plugging the new segment into the existing truss, removing the locks that held it steady during launch, and opening a latch to allow the P6 segment to be attached at the end when it is moved from its temporary location.

EVA No. 2 - Dec. 14: 5 hours.

Curbeam and Fuglesang exited Discovery again to start rewiring the station's power. Using power generated by the solar arrays delivered in September, they rewired channels two and three. Before the cable connections could be swapped, some of the station's systems, such as lights, communication gear, ventilation fans and backup computers, had to be shut down. In less than three hours, one of two external thermal control system loops was shedding excess heat into space and the DC-to-DC converter units were regulating power voltages.

Despite problems retracting the P6 solar array, the P4 arrays were able to rotate and track the sun, generating power for the station.

Curbeam and Fuglesang also were able to relocate two small handcarts on the rails of the station's main truss, put a thermal cover on the station's robotic arm, and install bags of tools for future spacewalkers.

EVA No. 3 - Dec. 16: 7 hours, 31 minutes.

Curbeam and Williams finished rewiring the station. They also installed a robotic arm grapple fixture and positioned three bundles of Russian debris shield panels outside the Zvezda service module, to be installed on a future spacewalk. Then the spacewalkers tackled grommets and guide wires on the P6 solar array and shook the array while the crew inside the station reeled it in one bay at a time. They achieved 65 percent retraction.

EVA No. 4 - Dec. 18: 6 hours, 38 minutes.

Curbeam and Fuglesang finished the P6 retraction, guiding the array into its blanket box. They were aided by Williams and Higginbotham who used the station's robotic arm to position the spacewalkers near the array. Afterward, the spacewalkers also secured multi-layer insulation that had been installed on the robotic arm during an earlier spacewalk.

The retraction set the stage for the spring 2007 shuttle mission, when the station's starboard overhead array will also be stowed. The arrays will be moved to the far end of the port truss on STS-120 and redeployed.

The crew wrapped up eight days of docked operations, separating from the space station on Dec. 19. On Dec. 20, they inspected the heat shield for possible micrometeoroid debris damage using the sensor-equipped orbiter boom sensor system unfolded from the payload bay. They also deployed small

technology demonstration satellites, known as MEPSI or Micro-Electromechanical System-based PICO-SAT Inspector, for the U.S. Department of Defense's Space Test Program, as well as student-experiment scientific satellites and the Atmospheric Neutral Density Experiment (ANDE) that will measure the density and composition of the low-Earth-orbit atmosphere while tracked from the ground.

On Dec. 21, Mission Control confirmed the shuttle's heat shield was in good shape and the crew and orbiter could plan for a safe landing.

2007

STS-117

*21st Space
Station Flight*

Atlantis



Pad A:

118th Shuttle mission
28th flight OV-104
51st landing at EAFB

Crew:

Rick Sturckow, commander (3rd shuttle flight)
Lee Archambault, pilot (1st)
Jim Reilly, mission specialist (3rd)
Patrick Forrester, mission specialist (2nd)
Steven Swanson, mission specialist (1st)
John "Danny" Olivas, mission specialist (1st)
Clay Anderson, Expedition 15/16 flight engineer, to ISS
Sunita Williams, Expedition 14/15 flight engineer, return from ISS after record 194 days, 18 hours, 58 minutes in space

Orbiter Preps:

OPF – Sept. 21, 2006
VAB – Feb. 7, 2007
Pad A – Feb. 15, 2007
Rollback to VAB – March 4
Pad A – May 15, 2007, 2nd time

Launch:

June 8, 2007, at 7:38:04 p.m. EDT.

The space shuttle Atlantis rocketed into a Florida twilight sky on time, kicking off the first of four shuttle missions scheduled for 2007. Atlantis' climb to orbit was flawless, carrying a seven-member crew.

The mission was delayed in February after the shuttle suffered hail damage on the 26th to tiles and the external tank. The decision was made to roll back the shuttle and make repairs in the VAB.

Landing:

June 22, 2007, at 3:49:38 p.m. EDT.

Atlantis landed on Runway 22 at Edwards Air Force Base in California, concluding a 13-day, 20-hour, 12-minute flight covering 5.8 million miles. The landing was diverted to California due to marginal weather at Kennedy. Main gear touchdown was at 3:49:38 p.m. EDT. Nose gear touchdown was at 3:49:49 p.m. and wheel stop was at 3:50:48 p.m. This was the 51st landing for the Space Shuttle Program at Edwards Air Force Base.

After preparations for a cross-country, piggy-back flight on a shuttle carrier aircraft, Atlantis left EAFB on July 1. Several fuel stops and weather delays brought Atlantis to KSC on July 3, touching down at 8:27 a.m. EDT.

Mission Highlights:

On June 8, the crew used the robotic arm to take a closer look at an area of an insulation blanket on the port orbital maneuvering system pod that was seen to be pulled away from adjacent thermal tiles. On June 9, Pilot Lee Archambault and Mission Specialists Patrick Forrester and Steve Swanson used the shuttle's robotic arm and an extension boom-mounted sensor system to inspect the heat shield on Atlantis' wing leading edges and nose cap.

Clay Anderson was transferred to the International Space Station as an official station crewmember of Expedition 15 and Flight Engineer Sunita Williams swapped places to join the Atlantis crew.

An issue surfaced during the mission with the Russian segment computers that provide backup attitude control and orbital altitude adjustments. Russian specialists worked with U.S. teams, troubleshooting and restoring computer capabilities. The shuttle's propulsion provided backup.

By June 15, Yurchikhin and Kotov got two of three lanes in both computers running after bypassing with external cabling what appeared to be a faulty power switch. They repeated the modification on the last two channels.

On June 18, the Russians were able to demonstrate the station's ability to maintain attitude control,

enabling the shuttle's departure.

Activation of the rotary joint provided use of four U.S. solar array wings tracking the sun during orbit of the station. Atlantis undocked from the station June 19, leaving behind 19 tons of food, water and equipment. A flyaround provided a good look at the reconfigured spacecraft. At a distance of 46 miles from the station, the shuttle robot arm and orbiter boom sensor system were used to inspect the thermal protection system on both wings and the orbiter's nose cap.

EVA No. 1 — June 11: 6 hours, 15 minutes

Mission Specialists Jim Reilly and Danny Olivas focused on the final attachment of bolts, cables and connectors to begin the activation of the S3/S4 truss segment and ready it for deployment of its solar arrays.

The spacewalk was delayed for about an hour after the station temporarily lost attitude control when the station's control moment gyroscopes went offline due to the mass of the new truss segment in the final stage of its attachment. The loss was not unexpected because of the station's skewed asymmetry as the 17.8-ton, bus-sized S3/S4 truss was being moved toward the S1 truss.

EVA No. 2 — June 13: 7 hours, 16 minutes

After station controllers unfurled the solar array attached to the newly installed S3/S4 truss segment on June 12 to soak up some sun, Forrester and Swanson removed all of the launch locks holding the 10-foot-wide solar alpha rotary joint in place.

The spacewalkers ran into a problem when Forrester tried to install a drive-lock assembly and found that commands being sent to it were actually being received by a drive-lock assembly installed during the mission's first spacewalk. Flight controllers confirmed that the drive-lock assembly installed earlier was in a safe configuration.

Spacewalkers also had to help retract an older solar array to clear the new array's path. All in all, 13 of the 31.5 solar array bays were folded.

EVA No. 3 — June 15: 7 hours, 58 minutes

Olivas spent two hours stapling and pinning down a thermal blanket on Atlantis' orbital maneuvering system, or OMS, pod. A 4-inch by-6-inch corner had peeled up during the launch.

Reilly installed the hydrogen vent valve of a new oxygen generation system on the Destiny laboratory.

Both Olivas and Reilly aided in retracting the P6 truss. The retraction sequence required 28 commands for a total of 45 to complete the task.

EVA No. 4 — June 17: 6 hours, 29 minutes

Forrester and Swanson retrieved a TV camera from a stowage platform attached to Quest and installed it on the S3 truss. They verified the drive-lock assembly 2 configuration and removed the last six solar alpha rotary joint launch restraints.

They cleared the path on the S3 truss for the mobile base system and began get-ahead tasks: installing a computer network cable on the Unity node, opening the hydrogen vent valve on the Destiny lab and tethering two orbital debris shield panels on the station's service module.

This was the 11th spacewalk completed in 2007.

STS-118

22nd Space Station Flight

Endeavour



Pad A:

119th shuttle mission
20th flight OV-105
65th landing at KSC

Crew:

Scott Kelly, commander (2nd shuttle flight)
Charlie Hobaugh, pilot (2nd)
Dave Williams, mission specialist (2nd)
Barbara R. Morgan, mission specialist (1st)
Rick Mastracchio, mission specialist (2nd)
Tracy Caldwell, mission specialist (1st)
Alvin Drew, mission specialist (1st)

Orbiter Preps:

OPF – Dec. 7, 2002 (STS-113 landing)
VAB – Jan. 9, 2004 (for OPF maintenance)
OPF-2 – Jan. 21, 2004 (return)
VAB HB-4 – Dec. 16, 2004
OPF-2 – Jan 12, 2005
SLF Hangar – Feb. 22, 2005 (for OPF modifications)
OPF – March 18, 2005 (return)
VAB – July 2, 2007 (rollover)
Pad A – July 11, 2007

Launch:

Aug. 8, 2007, at 6:36 p.m. EDT.

Launch was on time and Endeavour lifted off into an early evening sky before sunset. Endeavour carried a crew of seven, including teacher-turned-astronaut Barbara R. Morgan. The payload comprised the S5 truss, SPACEHAB module and external stowage platform 3 with a replacement control moment gyroscope, or CMG. This mission was the final one for the SPACEHAB module. Astronauts replaced the CMG for a faulty one on the International Space Station.

The launch returned Endeavour to active service after a three-year hiatus for major modifications. The work, conducted at KSC, included addition of a “glass cockpit,” a global positioning system for landing and the Station-to-Shuttle Power Transfer System, known as the SSPTS. The system enables the orbiter to draw power from the space station, enabling an extended stay for the mission.

Landing:

Aug. 21, 2007, at 12:32 p.m. EDT.

Endeavour landed on Runway 15 on the first opportunity after deorbit. Main gear touched down at 12:32:16 p.m. EDT. Nose gear touchdown was at 12:32:29 p.m. and wheel stop was at 12:33:20 p.m. Endeavour landed on orbit 201. STS-118 was the second of four shuttle missions planned for 2007.

Mission Highlights:

On Aug. 9, before docking on the space station, the crew took a close look at the heat shielding on Endeavour’s wing leading edges. They used the vehicle’s robotic arm and orbiter boom sensor system. On Aug. 10, Commander Scott Kelly also performed a backflip with the orbiter so the International Space Station crew could take digital photos of the orbiter’s underside, checking the tiles for damage.

The photography showed a 3-inch-round ding on the starboard underside and in-depth analysis showed damage occurred through the tile to the internal framework. After extensive engineering analyses and tests over several days, the mission management team decided not to direct a repair of the shuttle’s damaged tile before landing. All members of the team believed that leaving the damaged tile “as is” did not pose a risk to the crew during re-entry.

The shuttle and space station docked at 2:02 p.m. EDT while traveling 214 miles above the southern Pacific Ocean, northeast of Sydney, Australia.

Mission managers first extended the flight to 14 days after successfully drawing power from the station via the SSPTS. The extension enabled a fourth

spacewalk. Later, concern over Hurricane Dean’s movement toward Texas caused mission managers to end the mission one day early.

Astronauts participated in a first for the space station. Mission Specialists Tracy Caldwell and Morgan installed a 7,000-pound storage platform using only the station’s and shuttle’s robotic arms. The stowage platform was attached to the P3 truss.

During the spacewalks, astronauts installed the S5 truss, a gyroscope and external stowage platform No. 3.

The mission also included three educational events featuring teacher-turned-astronaut Morgan. On several occasions, Morgan and other astronauts answered questions from children from the Discovery Center in Boise, Idaho, the Challenger Center for Space Science Education in Alexandria, Va., and in Saskatchewan, Canada.

On Aug. 11, the station’s primary U.S. Command and Control computer shut down unexpectedly at 2:52 p.m. The redundant system reacted as designed and the primary backup computer took over, and the third computer moved into the backup slot. The shutdown did not affect the spacewalk. Station flight controllers brought up the third computer later after determining an errant software command was the cause of the shutdown.

EVA No. 1 — Aug. 11: 6 hours, 17 minutes

First-time spacewalkers, Mission Specialists Rick Mastracchio and Dave Williams added the two-ton, 11-foot-long spacer, the Starboard 5 segment of the space station’s truss. They also retracted the forward heat-rejecting radiator from the P6 truss, which will be relocated to the end of the port truss during the STS-120 mission.

EVA No. 2 — Aug. 13: 6 hours, 28 minutes

Williams and Mastracchio installed the 600-pound control moment gyroscope onto the Z1 segment of the station’s truss, storing the failed unit outside the station. It will be returned to Earth on a future mission. This was the 90th spacewalk devoted to station maintenance and construction.

EVA No. 3 — Aug. 14: 5 hours, 28 minutes

Mastracchio and Expedition 16 Flight Engineer Clay Anderson relocated the S-band antenna sub-assembly from P6 to P1, installed a new transponder on P1 and retrieved the P6 transponder. Pilot Charlie Hobaugh and station Flight Engineer Oleg Kotov moved two CETA cards, enabling future relocation of a solar array segment on mission STS-120.

During the EVA, Mastracchio noted a hole on the thumb of his left glove. The hole was in the second of five layers and did not cause any

leak or danger to Mastracchio. However, as a precaution, he returned to the Quest airlock while Anderson completed his final task.

EVA No. 4 — Aug. 18: 5 hours

Williams and Anderson installed the External Wireless Instrumentation System antenna, attached a stand for the shuttle's robotic arm extension boom and retrieved the two materials experiment containers to be brought home on the shuttle. Two other tasks originally planned for the spacewalk – cleaning up and securing debris shielding and moving a toolbox to a more central location – were deferred to a future spacewalk.

STS-120

*23rd Space
Station Flight*

Discovery



Pad A:

120th shuttle mission
34th flight of OV-103
66th landing at Kennedy Space Center

Crew:

Pam Melroy, commander (3rd shuttle flight)
George Zamka, pilot (1st)
Scott Parazynski, mission specialist (5th)
Doug Wheelock, mission specialist (1st)
Stephanie Wilson, mission specialist (2nd)
Paolo Nespoli, ESA, mission specialist (1st)
Daniel Tani (2nd), up to ISS
Clay Anderson, down from ISS

Orbiter Preps:

OPF – Dec. 22, 2006 (STS-116 landing)
OPF Rollout – Sept. 23, 2007
VAB Rollout – Sept. 30, 2007

Launch:

Oct. 23, 2007, at 11:38 a.m. EDT.

Launch was on time and Discovery lifted off into a partly clouded sky, heading for the International Space Station on the 23rd assembly flight.

Landing:

Nov. 7, 2007, at 1:01 p.m. EST.

Discovery landed on Runway 33 at Kennedy Space Center. Main gear touchdown was 1:01:16 p.m. EST. Wheel stop was at 1:02:07 p.m. Mission elapsed time was 15 days, 2 hours, 24 minutes and 2 seconds, covering 6.5 million miles.

Mission Highlights:

During the mission, the STS-120 crew continued the construction of the station with the installation of the Harmony Node 2 module and the relocation of the P6 truss.

Station managers added a 360-degree visual inspection of the station's starboard solar alpha rotary joint, or SARJ, during the second spacewalk. The SARJ had shown increased friction for more than 30 days.

An extra day was added to the mission between the fourth and fifth spacewalks to provide the crew off-duty time and equipment preparation for the fifth spacewalk.

However, the objective of the fourth spacewalk changed in order to repair the torn solar array and the fifth spacewalk was transferred to the station crew to perform after the shuttle left.

Teams on the ground worked around the clock to develop a plan for the repair. Astronauts constructed solar array hinge stabilizers using strips of aluminum, a hole punch, a bolt connector and 66 feet of wire. Working like a cuff link, the wire would feed through a hole on the solar array and be supported by the strip of aluminum.

They also positioned the station's mobile transporter and robotic arm at the end of the truss to serve as a base and "cherry picker." Crew members insulated tools with Kapton tape to protect against electrical currents.

EVA No. 1 — Oct. 26: 6 hours, 14 minutes

Mission Specialists Scott Parazynski and Doug Wheelock installed the Harmony module in its temporary location, readied the P6 truss for its relocation two days later, retrieved a failed radio communications antenna and snapped shut a window cover on Harmony that had opened during launch.

EVA No. 2 — Oct. 28: 6 hours, 33 minutes

Parazynski and flight engineer Daniel Tani disconnected cables from the P6 truss to enable it to be removed from the Z1 truss.

Tani inspected the SARJ and collected "shavings" he found under the joint's multi-layer insulation covers. Mission managers limited

the use of the SARJ while they assessed the anomaly.

The spacewalkers also outfitted the Harmony module, mated the power and data grapple fixture and reconfigured connectors on the S1 truss that will allow the radiator on S1 to be deployed from the ground at a later date.

EVA No. 3 — Oct. 30: 7 hours, 8 minutes

Parazynski and Wheelock installed the P6 truss segment with its set of solar arrays to its permanent home. They installed a spare main bus switching unit on a stowage platform for future use if needed.

Parazynski looked at the port SARJ to compare with the starboard joint. The port SARJ was clean.

When the P6 solar arrays were deployed at the end of the spacewalk, a tear appeared in a blanket. Deployment was halted so engineers could analyze what steps to take next.

Despite the 80-percent deployment, the array was producing nearly normal power.

After reentering the station, Wheelock noticed a small hole in the outer layer of his right glove thumb. Options would be considered before his next spacewalk.

EVA No. 4 — Nov. 1: 7 hours, 19 minutes

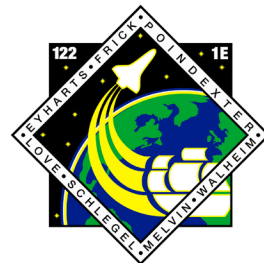
Prior to leaving the station, the orbiter boom sensor system was moved from the shuttle's robotic arm to the station arm. Parazynski and Wheelock then took 90 minutes to ride the arm to the torn array -- 165 feet down the truss and 90 feet up to the damage. Parazynski cut a snagged wire and installed homemade stabilizers to strengthen the array's structure and stability where the damage occurred. Ground controllers then were able to finish the deployment begun on Oct. 30 in increments of one half bay at a time. The procedure took 15 minutes.

Before the undocking, the shuttle crew transferred items to the shuttle: 2,020 pounds of equipment and scientific samples, including the metal shavings from the SARJ for engineers to study and try to determine the cause of resistance in the starboard rotary joint.

Discovery backed away from the station at 5:32 a.m. EST on Nov. 5.

2008

STS-122 *(24th Space Station Flight)*



Atlantis

Pad A:

121st shuttle mission
29th flight of OV-104
67th landing at KSC

Crew:

Steve Frick, commander (2nd shuttle flight)
Alan Poindexter, pilot (1st)
Rex Walheim, mission specialist (2nd)
Stanley Love, mission specialist (1st)
Leland Melvin, mission specialist (1st)
Hans Schlegel, mission specialist (2nd),
represents European Space Agency
Leopold Eyharts, mission specialist (1st),
up to ISS
Daniel Tani, flight engineer, down from ISS

Orbiter Preps:

OPF Roll-In – July 4, 2007, after ferry-flight from Dryden and arrival July 3
OPF Rollover – Nov. 3, 2007
VAB Rollout – Nov. 10, 2007

Launch:

Feb. 7, 2008, at 2:45 p.m. EST.

The STS-122 mission was twice delayed in December 2007 after false readings occurred in the engine cut-off sensor system while Atlantis' external fuel tank was being filled. Tests revealed that open circuits in the external tank's electrical feed-through connector were the most likely cause. A modified connector, designed with pins and sockets soldered

together, was installed for the mission. The sensor system is one of several that protects the shuttle's main engines by triggering their shut down if fuel runs unexpectedly low.

The launch date was then reset to Feb. 7. The sensor system was flawless during liftoff.

Landing:

Feb. 20, 2008, at 9:07 a.m. EST.

Atlantis landed on Kennedy's Runway 15 after a journey of nearly 5.3 million miles. Main gear touchdown was 9:07:10 a.m. Nose gear touchdown was 9:07:20 a.m. Wheel stop was at 9:08:08 a.m. Mission elapsed time was 12 days, 18 hours, 21 minutes and 44 seconds.

Mission Highlights:

The mission delivered and installed the European Space Agency's Columbus laboratory, whose experiments will be coordinated by a data center to manage the research and collect its results. The Columbus Control Centre is in Oberpfaffenhofen, Germany.

During docking, one of the five computers on the International Space Station experienced problems with guidance and navigation software. The crew used other computers for the shuttle's rendezvous; only one computer is needed for the rendezvous, with one required for backup.

After docking with the space station, Mission Specialist Leopold Eyharts moved onto the orbiting outpost as the newest Expedition 16 crew member and flight engineer Dan Tani returned to the shuttle in his place.

The first spacewalk was postponed a day due to a medical issue with Mission Specialist Hans Schlegel. It was determined that Mission Specialist Stanley Love would take Schlegel's place on the spacewalk.

Close scrutiny of images of the thermal protection system on Atlantis revealed minor damage to a thermal blanket over the shuttle's right orbital maneuvering system pod. Mission managers eventually cleared the shuttle's thermal protection system for re-entry based on inspections.

Mission managers extended the mission an extra day to continue activation of the Columbus laboratory.

The shuttle and station crews spoke with German Chancellor Angela Merkel, ESA Director General Jean-Jacques Dordain and former astronaut Thomas Reiter, who is now a member of the German Space Agency, DLR.

installed a grapple fixture on Columbus in the payload bay and prepared electrical and data connections on the module. Astronauts Leland Melvin, Tani and Eyharts used the space station's robotic arm to grab Columbus, lift it out of the orbiter and move it to the starboard side of the station. Walheim and Love also began work to replace a large nitrogen tank used for pressurizing the station's ammonia cooling system.

EVA No. 2 — 6 hours, 45 minutes, Feb. 13.

Walheim and Schlegel replaced the nitrogen tank and, using the station's robotic arm, placed the spent tank into Atlantis' payload bay. The astronauts then made minor repairs to the Destiny laboratory debris shield and worked on tasks to prepare for the final spacewalk.

EVA No. 3 — 7 hours, 25 minutes, Feb. 15.

Guided by Pilot Alan Poindexter, Walheim and Love transferred the first of two external experiment facilities, called SOLAR, to Columbus for installation. Melvin operated the station's robotic arm for the transfer. The astronauts also retrieved a stored failed gyroscope and moved it into Atlantis' payload bay for return to Earth. They then installed a second experiment onto Columbus, the European Technology Exposure Facility, or EuTEF. Finally, Walheim and Love examined a damaged handrail on the outside of the Quest airlock. They rubbed a tool covered with spacewalk overglove material over it to see if the handrail could be the source of glove abrasions occurring during recent activity outside the station.

All crew members worked to activate and initialize the Columbus laboratory, outfitting it with experiment racks.

Atlantis' propulsion system was used to reboost the station's altitude by about 1.4 miles -- the first reboost of the station using shuttle thrusters since 2002 -- to achieve proper alignment of the station in advance of the March arrival of space shuttle Endeavour on the STS-123 mission.

Hatches between the station and Atlantis were closed at 1:03 p.m. EST on Feb. 17. Atlantis undocked at 4:24 a.m. EST on Feb. 18.

EVA No. 1 — 7 hours, 58 minutes, Feb. 11.

Love and Mission Specialist Rex Walheim



The International Space Station after installation of the S3/S4 truss segment during mission STS-117 in June 2007.

National Aeronautics and Space Administration

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